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Achieving the SDGs: Evaluating indicators to be used to benchmark and monitor progress towards creating healthy and sustainable cities

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ABSTRACT

In 2016, the World Health Organization declared that 'Health is one of the most effective markers of any city's successful sustainable development' (World Health Organisation, 2016). With estimates that around 6.7 billion people will live in cities by 2050, 21st century city planning decisions will play a critical role in achieving the United Nations (UN) Sustainable Development Goals (SDGs). They will determine the city structure and access to health-enhancing (or health-damaging) urban environments, and ultimately lifestyle choices that impact both individual and planetary health. Benchmarking, monitoring and evaluating city planning policies and interventions is therefore critical to optimise urban outcomes. In 2017, the UN adopted a global SDG indicator framework, calling for complementary national and regional indicators to be collected by member countries. UN Habitat has also developed an indicator action framework specifically for cities. This paper examined the extent to which the UN indicators will help cities evaluate their efforts to deliver sustainability and health outcomes. It identified inconsistencies between the two UN indicator frameworks. Many of the SDG indicators assess outcomes, rather than the comprehensive and integrated 'upstream' policies and interventions required to deliver outcomes on-the-ground. Conversely, the UN Habitat framework incorporates intervention indicators, but excludes health outcome indicators. A more comprehensive approach to benchmarking, monitoring and evaluating policies designed to achieve healthy and sustainable cities and assessing spatial inequities is proposed.

1. Introduction

While cities are the powerhouse of economies, providing opportunities for education and employment, across the globe they are struggling to manage population growth, traffic congestion, housing affordability and air quality [4]. Cities already generate 70% of global greenhouse gas emissions [3], and this is likely to increase as the percentage of people living in cities grows. In the century preceding 2050, it is estimated that urban populations will more than double - from 30% in 1950 to an estimated 68% in 2050 [2].

One's residential location within cities is a powerful determinant of social and health inequity, affecting access to infrastructure and employment, as well as consumption patterns, environmental footprint, and vulnerability to natural hazards. It is now recognised that creating healthy and sustainable cities with equitable access to services and infrastructure for daily living requires integrated planning and governance across multiple sectors [5–8]. Yet this approach to city planning is difficult to achieve in practice. Integrated planning requires integrated knowledge, and urban indicators are a commonly used tool to frame this knowledge. However, indicators of city planning outcomes provide little insight into the presence or absence of policies that created problems, or how problems can be ameliorated. In addition, overall city-wide indi-

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cators can mask inequities within cities. In this paper we examine the extent to which indicators developed by the United Nations (UN) to measure progress against the Sustainable Development Goals (SDGs) will help achieve healthier, more sustainable cities. This demonstrates the need for an alternative approach to benchmarking and monitoring progress towards creating healthy cities and addressing spatial inequities.

1.1. City planning, health and the sustainable development agenda

With an emphasis on partnerships, the 2030 Agenda for Sustainable Development and the associated UN SDGs were established in 2015 as an action plan to reduce poverty, create a healthy planet and ensure a prosperous and peaceful future for all [7]. With 17 goals and 169 targets, they provide a blueprint for actions that could (and should) take place to achieve sustainable development. While Goal 11 specifically relates to Sustainable and Resilient Cities and Human Settlements, given rapid urbanisation, cities are generally recognised as key to successfully implementing the whole SDG agenda [8].

City planning decisions affect the health, wellbeing and safety of urban populations; [6] and the link between sustainable development, climate change and health is now firmly established [9,10]. Indeed, in its 2016 Shanghai Declaration the World Health Organisation (WHO) declared that health is one of the most 'effective markers' of a city's sustainable development [1,11], reinforcing its decades-old position on the need for 'healthy cities' [12], and the conclusions of its 2008 Commission on Social Determinants of Health - that health and health equity should be at the heart of city planning [13]. This is not surprising given that 40% of non-communicable diseases are preventable [14] and that sectors outside of health – including city planning – create the conditions for good (and bad) health.

A recent Lancet series on urban design, transport and health [6] sought to conceptualise how city planning decisions affect transport and health outcomes. Fig. 1 presents a modified version of this conceptual framework [6], taking into account some of the broader outcomes being sought by the SDGs that might directly influence health outcomes. Fig. 1 outlines the pathways through which urban systems policies (that is, the most 'upstream' determinants of health [15]) shape urban design and transport planning interventions, and transport mode and daily living choices [6]. These in turn determine more 'downstream' [15] physical and mental health risk exposures such as traffic, air pollution, physical inactivity, social isolation, safety and unhealthy diets, which impact intermediate outcomes such as obesity, traffic accidents, greenhouse gas emissions; and ultimately longer-term health, sustainability and liveability outcomes. However, these outcomes are often unevenly distributed across cities, caused – in part – by the inequitable implementation of city planning policies and interventions. This is important because individual and area-level socioeconomic disadvantage are underlying determinants of mortality and morbidity and affect health inequities, as indicated in Fig. 1 [6].

In recognition of the critical role that cities will play in achieving the SDGs, the UN Habitat's New Urban Agenda (NUA) [16] was established in 2016. This broad, non-binding international agreement is aimed at transforming the ways cities are 'planned, designed, financed, developed, governed and managed' to achieve sustainable development. Adopted by UN member states at the Habitat III Conference on Housing and Sustainable Urban Development [17], the NUA is the third UN-led international urban development agreement, superseding the 1976 Vancouver Declaration on Human Settlements [18], and the 1996 Habitat Agenda [19]. The attendance of 45,000 delegates at the Habitat III conference is indicative of the global interest in cities as locations for improving quality of life, health and protecting the environment. Hence, the NUA [16] has been devised as the key mechanism for implementing the SDGs in cities [7], especially but not exclusively Goal 11.

Reflecting the SDGs, health is one key focus of the NUA [20–22], with human health identified as a desirable outcome of sustainable urban development. Perhaps more importantly however, the NUA addresses structural determinants of healthy cities such as poverty, social marginalisation, housing security, environmental degradation, and access to employment, transport, and social and health infrastructure [16,23]. While the NUA discusses the upstream mechanisms to achieve these determinants such as urban and transport planning, design and governance, as a non-binding agreement, it does not detail the specific mechanisms and interventions required. Nevertheless, well implemented policies aligned with the NUA, could have a major impact on the health and wellbeing of urban residents [10]. The NUA also calls for quantitative and qualitative monitoring and regular reporting of progress towards sustainable development of cities [24].

There is growing global interest in using indicators to assess progress on achieving the SDGs. In 2017, UN member states endorsed a global indicator framework for measuring progress on implementing the 17 SDGs and associated targets. The SDG indicators will be refined annually and reviewed in 2020 [25]. The SDG indicator framework has subsequently been refined specifically for cities by UN Habitat in its *Action Framework for Implementation of the New Urban Agenda* [26]. This Action Framework [26] goes beyond Goal 11 with its focus on cities and human settlements, to include indicators of other SDGs that have urban-based targets. It also incorporates a number of city-specific indicators from its 2012 City Prosperity Initiative [27].

Disaggregating indicators measuring achievement of the SDGs is a priority, given that reducing inequity is a major theme of the SDGs, and vital for improving population health [7]. For example, SDG Goal 1 relates to ending all forms of poverty (everywhere); Goal 3 references health 'for all'; Goal 4 focuses on access to 'inclusive and equitable' education; Goal 5 seeks to achieving gender equality; Goal 8 relates to inclusive and sustainable economic growth and decent work for all; Goal 10 aims to reduce inequality within and among countries; and Goal 16 includes 'justice for all'. Reducing inequities is consistent with aspirations of other multilateral agencies. For example, the WHO and UN Habitat [28] have highlighted the need for inequities within cities to be unmasked and overcome.

1.2. Aim and approach to assessing indicators

To achieve the SDGs, cities will need to develop and implement transformational policy, regulatory and legislative frameworks in order to deliver outcomes on-the-ground [8]. Integrated policy and investment across multiple sectors (e.g., housing, economic development, transport, education, urban design, finance) and levels of government, will be required to deliver healthy, liveable and sustainable cities [5,6,29,30]. Moreover, to benchmark and monitor change over time, there is a need for indicators that not only measure the downstream outcomes of urban policies (e.g. air quality), but also the upstream policies (e.g. the presence or absence of air quality legislation) and pathways of influence (e.g. implementation of interventions to reduce polluting forms of transport).

Hence, the main aim of this paper was to review and critique the SDG and NUA indicator frameworks to determine the extent to which they adequately measure both the upstream and downstream pathways that will produce desirable health outcomes in cities. The indicator frameworks were independently reviewed by two of the authors (ML and BGC), and any differences were discussed before finalising with the final arbiter (JA). Using the city

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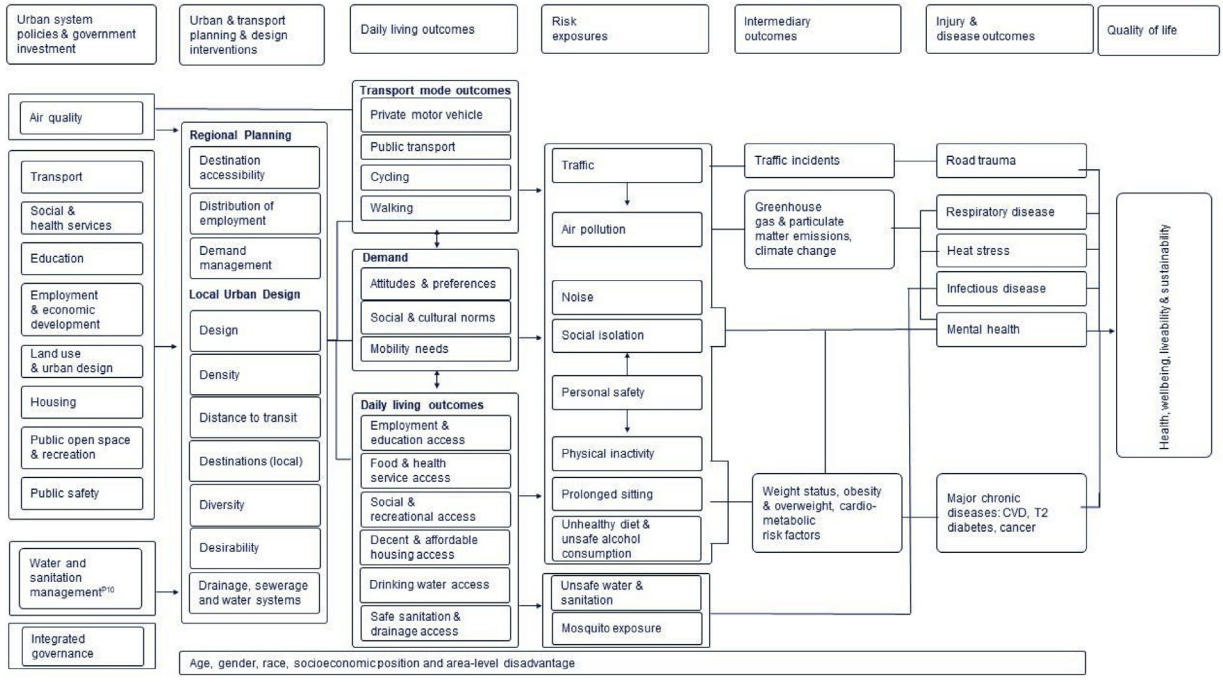

Fig. 1. Conceptual framework outlining pathways through which city planning decisions affect health and sustainability outcomes.
Source: Modified from Giles-Cort et al. [6].

planning and health framework in Fig. 1 (modified from Giles-Corti et al. [6]) to guide the analysis, the review identified: (1) which indicators relate specifically to city planning and health; and (2) if so, the specific aspect of the health determinants pathway they measure. We also assessed whether the indicators had the potential to be spatially disaggregated, as overall national and city-wide indicators mask inequities within cities [28], and mapping would uncover spatial inequities within and between cities. Finally, using Australia as a case study we examined how indicators are being used to benchmark and monitor Australian cities, and considered additional indicators that could be used globally to evaluate progress towards achieving healthier and more sustainable cities.

2. Review of the SDG and NUA indicator frameworks

The UN SDG global indicator framework includes 244 indicators across its 17 goals and 169 targets. Nine of these indicators are repeated under two or more different targets, resulting in 232 unique indicators. Six percent (14/244) of all indicators are for Goal 11 (the cities and human settlements SDG).

Given our focus on city planning and health, we assessed indicators for all of the SDGs against Fig. 1, to explore whether they specifically relate to the pathways through which city planning influences health. We found that 27 of the 244 (11%) SDG indicators are related to city planning and health. However, only 33% of these health-related indicators were for Goal 11 – the cities and human settlements SDG (see Table 1). Twenty two percent of the city planning and health indicators were derived from Goal 3 and 14% from Goal 16. Three other Goals (2,6 and 9) each accounted for 7% of the city planning and health indicators.

Despite the importance of spatial planning for the achievement of many of the other SDGs, no specific indicators relevant to city planning and health were identified for nine SDGs. Most notable were those that determine spatial access to amenities, services and processes required for daily living, including Goals 4, 8, 12, 13 and 17. This suggests that there is limited understanding of the contribution of these SDGs to spatial planning of healthy cities.

The limitations of the UN SDG global indicator framework from a city planning perspective have been recognised by the UN Habitat. As discussed above, its *Action Framework for Implementation of the New Urban Agenda* [26] includes 85 'NUA Indicators', with 48 of these being from the UN SDG global indicator framework; and 37 from the City Prosperity Initiative [27]. When assessed against Fig. 1, our review identified that 34 of the 85 indicators (40%) were specifically relevant to city planning and health (see Table 1). Of these, 18 were SDG indicators (the NUA Indicators do not include all SDG indicators) and 16 (47%) were derived from the City Prosperity Initiative.

2.1. Locating the SDG and NUA indicators on the causal pathway

As suggested earlier, integrated planning is required to create healthy liveable cities. Modified from Giles-Corti et al. [6] Fig. 1 presented a conceptual framework of the hypothesized causal pathways through which upstream urban policy influences downstream outcomes. In Table 2, we identify which aspects of the city planning and health pathway that the SDG and NUA indicators attempt to measure, according to this conceptual framework.

As can be seen in Table 2, the SDG and NUA frameworks together include five indicators measuring urban system policies and government investment, 13 indicators of urban and transport planning and design interventions, seven indicators of daily living outcomes, 11 indicators of risk exposures, one of intermediary outcomes; and six indicators of injury and disease outcomes. The five common indicators measuring upstream determinants of healthy and sustainable cities include two urban systems policies and three government investment indicators. Both of the urban systems policy indicators while important, are general rather than specific: one measures the implementation of urban and regional plans integrating population projections and resource needs; while the other is concerned with civil society's participation in urban planning and management. The three government investment indicators measure: (1) international support to infrastructure; (2) government expenditure by sector; and (3) public and private expenditure per

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Table 1
SDG goals and indicators relevant to city planning and health.

SDG Goal	Sustainable Development Goal (SDG) global indicator framework				New Urban Agenda Action Framework Indicators		
	Total (n = 244)	% total (n = 244)	Relevant to city planning and health (n = 27)	% of total relevant to city planning and health (n = 27)	Total[a] (n = 85)	Relevant to city planning and health (n = 34)	% of total relevant to city planning (n = 34)
Goal 1 End poverty in all its forms everywhere	14	6	1	4	2	1	3
Goal 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture	13	5	2	7	1		
Goal 3 Ensure healthy lives and promote well-being for all ages	27	11	6	22	1	1	3
Goal 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	11	4					
Goal 5 Achieve gender equality and empower all women and girls	14	6			2		
Goal 6 Ensure availability and sustainable management of water and sanitation for all	11	4	2	7	3	2	6
Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all	6	2			2		
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	17	7			3		
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	12	5	2	7	5	2	6
Goal 10 Reduce inequality within and among countries	11	4			2		
Goal 11 Make cities and human settlements inclusive, safe, resilient and sustainable	15	6	9	33	14	9	26
Goal 12: Ensure sustainable consumption and production patterns	13	5			3		
Goal 13: Take urgent action to combat climate change and its impacts	8	3					
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	10	4					
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	14	6	1	4	2	1	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to just for all and build effective, accountable and inclusive institutions at all level	23	9	4	14	5	2	6
Goal 17: Strengthen the means of implementation and revitalize the Global Partnerships for Sustainable Development	25	10			3		
Additional City Prosperity Initiative indicators [27]					37	16	47

[a] Combines indicators in the UN-Habitat's Action Framework for Implementation of the New Urban Agenda in total, and its Annex 1 (partial list) [26].

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Table 2
SDG and NUA indicators for cities globally by upstream-downstream indicator categories.

Indicator type[a]	SDG and NUA Indicators relevant to city planning and health			Can be spatially disaggregated to measure inequities within cities, where appropriate data are available?	Location in Fig. 2 framework
	Measure	SDG Indicator	NUA Indicator[b]		
URBAN SYSTEM POLICIES AND GOVERNMENT INVESTMENT[c]	11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically	√	√	No	P11
	11.a.1 Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city	√	√	No	P11
	9.a.1 Total official international support (official development assistance plus other official flows) to infrastructure	√	√	No	P2-P10
	16.6.1 Primary government expenditures as a proportion of original approved budget, by sector (or by budget codes or similar)	√	√	Yes for local, government, no for state or national government	P1-P10
	11.4.1[d] Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all . . ..natural heritage, by type of heritage. . .., level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)	√	√	Yes	P8
URBAN AND TRANSPORT PLANNING AND DESIGN INTERVENTIONS	11.3.1 Ratio of land consumption rate to population growth rate	√	√	Yes	RP
	CPI-ID 4.3 Length of mass transport network		√	Yes	RP1
	CPI-ID 4.2 Average daily travel time		√	Yes	RP1
	CPI-P-2.1 Economic density		√	Yes	RP2, LUD4, LUD5
	CPI-ID 5.1 Street intersection density		√	Yes	LUD1
	CPI-ID- 5.2 Street density		√	Yes	LUD1
	CPI-ID-5.3 Land allocated to streets		√	Yes	LUD1
	CPI-ID-1.6 Residential density		√	Yes	LUD2
	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	√	√	Yes	LUD3
	11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities	√	√	Yes	LUD4
	15.1.1 Forest area as a proportion of total land area	√	√	Yes	LUD4
	CPI-ES 3.1 Share of protected area in natural systems that provide basic ecosystem services		√	Yes	LUD4
	CPI-ESI 4.1 Land use mix		√	Yes	LUD5
DAILY LIVING OUTCOMES	9.1.2 Passenger and freight volumes, by mode of transport	√	√	Yes	DL1-4
	1.4.1 Proportion of population living in households with access to basic services	√	√	Yes	DL2, DL8-14
	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing	√	√	Yes	DL11
	CPI-ESI 2.1 Slum households		√	Yes	DL11
	CPI-ID-1.1 Improved shelter		√	Yes	DL11
	CPI-ID-1.2 Access to improved water		√	Yes	DL13
	CPI-ID-1.3 Access to improved sanitation		√	Yes	DL14
RISK EXPOSURES	11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)	√	√	Yes	R2
	CPI-ES 1.2 PM10 concentration (reserved)		√	Yes	R2
	CPI- ES 1.3 CO2 emissions (reversed)		√	Yes	R2
	11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months	√	√	Yes	R5
	16.1.1 Number of victims of intentional homicide per 100,000 population, by sex and age	√		Yes	R5
	16.1.3 Proportion of population subjected to (a) physical violence,. . . and (c) sexual violence in the previous 12 months	√		Yes	R5
	16.1.4 Proportion of population that feel safe walking alone around the area they live	√	√	Yes	R5
	2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)	√		Yes	R8

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Table 2 (*Continued*)

Indicator type[a]	SDG and NUA Indicators relevant to city planning and health			Can be spatially disaggregated to measure inequities within cities, where appropriate data are available?	Location in Fig. 2 framework
	Measure	SDG Indicator	NUA Indicator[b]		
	3.5.2 Harmful use of alcohol, defined according to the national context as alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol	√		Yes	R9
	6.1.1 Proportion of population using safely managed drinking water services	√	√	Yes	R10
	6.2.1 Proportion of population using (a) safely managed sanitation services. . .	√	√	Yes	R11
INTERMEDIARY OUTCOMES	2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)	√		Yes	IO3
INJURY AND DISEASE OUTCOMES	3.6.1 Death rate due to road traffic injuries	√	√	Yes	O1
	CPI-ID 4.4 Traffic fatalities (reversed)		√	Yes	O1
	3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation. . .	√		Yes	O4
	3.3.3 Malaria incidence per 1000 population	√		Yes	O4
	3.9.1 Mortality rate attributed to. . .ambient air pollution	√		Yes	O2, O5, O6
	3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease	√		Yes	O6

[a] Indicator framework based on Giles-Cort et al. [6].
[b] Combines indicators in UN-Habitat's Action Framework for Implementation of the New Urban Agenda in total, and its Annex 1 (partial list) [26].
[c] Investments represented as dotted line boxes in the urban systems policies and government investments column in Fig. 2.
[d] This indicator also included cultural heritage, but this was assessed as less relevant to city planning and health.

capital on preserving, protecting and conserving natural heritage. Again, with the exception of the latter, these investment indicators are non-specific, and do not stipulate the particular infrastructure, projects or sectors of interest to city planning. While natural heritage is given prominence as a critical urban system in the latter investment indicator, no specific emphasis is placed on other key urban systems (e.g. policies and expenditure on housing provision, different transport modes, air quality, education or social services) that would help achieve more downstream SDGs related to health and environmental outcomes.

To provide a visual representation, the results are mapped onto the framework in Fig. 2. The cross-hatching-coding indicates whether a component of the framework is measured by the SDG indicators, the NUA Indicators, both or neither framework. Fig. 2 illustrates that the SDG global indicator framework focuses more on downstream outcomes, rather than the technical, regulatory and legislative frameworks required to deliver on-the-ground interventions that will help to achieve the SDGs in cities. Indeed, 56% of the indicators from the SDG framework measure downstream health risk exposures (n = 9) and health outcomes (n = 6) related to city planning (see Table 2). Only 11% measure daily living outcomes (n = 3) and only 15% measure urban and transport planning and design interventions (n = 4, with two of these measuring forest and open space areas).

In comparison, the NUA Indicators (which include City Prosperity Initiative indicators alongside the SDG indicators) incorporate fewer health risk factor and outcomes indicators, shifting the emphasis towards more upstream determinants of health and environmental outcomes, particularly the implementation of urban and transport planning and design interventions (see Table 2 and Fig. 2). Overall, 38% of the NUA Indicators measure urban and transport planning and design interventions (n = 13); 21% daily living outcomes (n = 7); and 21% health risk exposures (n = 7). Very few (only 6%; n = 2) of the indicators measure injury and disease outcomes (see Table 2).

2.2. Potential for spatial disaggregation

The *Hidden Cities* report by the WHO and UN Habitat [28] emphasises the importance of unmasking and acting upon inequities within cities. There are many ways indicators can be disaggregated in order to measure inequities in opportunities (e.g., gender, race, ethnicity, socioeconomic status, age). However, for city planning decision-makers, disaggregated *spatial* indicators are needed to assess and map inequitable access to infrastructure and services, and the health and other outcomes of city planning decision-making. For example, a metropolitan-wide indicator could report on the percentage of households within 400 m of public open space. However, this provides no indication about whether some areas (e.g. higher socioeconomic areas) have better access to public open space than others. Spatial indicators can be aggregated at different scales ranging from the immediate area surrounding a household address (i.e. the 'neighbourhood'), to an administrative unit (e.g. a census tract), a suburb or a whole municipality [28]. The choice of aggregation will be influenced by the research or policy question and/or the specific interests of the decision-maker reviewing the spatial mapping of the indicators. For example, in the Australian context, while the federal government might be satisfied with city-wide levels of aggregation, local government authorities (LGA) typically prefer data provided at sub-LGA aggregation.

Nevertheless, spatial disaggregation may not be possible because appropriate data may not be available in many cities, particularly in low- and middle-income countries. This issue is considered further in Section 4 below. Also, spatial disaggregation is not relevant for some urban policy and investment indicators. For example, the presence or absence of a policy might need to be assessed at the geographical scale relevant to the particular level of government responsible for the policy (e.g. national, state or local government). However, to identify inequities in policy implementation across a city and areas requiring investment, disaggregated spatial indicators would appear to be important.

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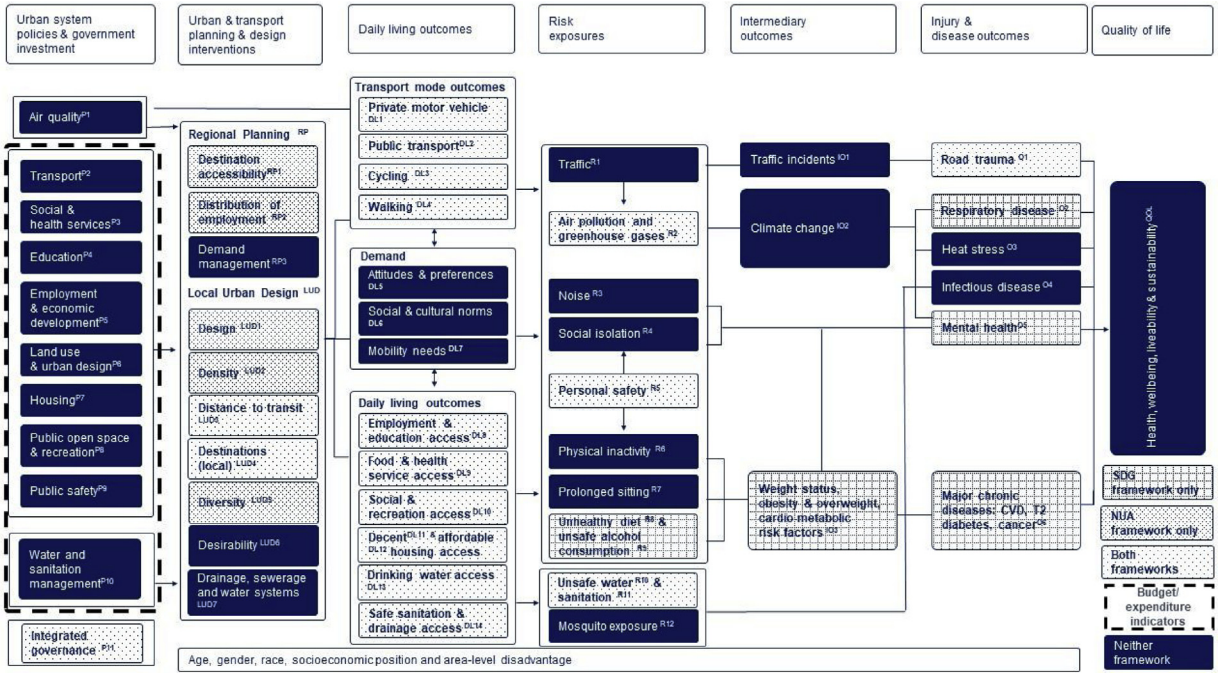

Fig. 2. The SDG and NUA Indicators mapped against the conceptual framework of how city planning decisions affect health and sustainability outcomes. Source: Modified from Giles-Corti et al. [6].

When all SDG indicators were reviewed, we found that if appropriate data were available, only 119 of the 244 (48.8%) could be spatially disaggregated to measure inequities within cities. Those that could not be disaggregated were those measured at a large scale (e.g. national or number of countries) or which related to overall national or state policy or funding.

However, when just the indicators related to city planning and health are considered, a different picture emerges. Subject to the availability of data, the majority of the city-planning related SDG indicators (24 out of 27; 88.9%) could be spatially disaggregated to assess inequities within cities (see Table 2); as could 31 of the 34 city planning-related NUA Indicators (91.1%).

To illustrate the importance of spatial disaggregation of indicators for assessing inequities, a case study of public transport indicators adopted in Australia is now considered. The case study highlights how city planning policies will impact the realisation of the SDGs, and how indicators can be operationalised to monitor policy implementation.

3. Case study: Public transport indicators for Australian cities

Public transport connects people with employment, education and social opportunities and its importance in achieving the SDGs is recognised in Goal 11 and target 11.2: 'by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons'. The SDG indicator (11.2.1) for public transport is the 'proportion of population that has convenient access to public transport, by sex, age and persons with disabilities' [24]. To maximise the proportion of residents with access to public transport, integrated land use and transport planning is required.

A recent study reviewed state government policies on planning and delivery of public transport in Australia's four largest cities. It found that all cities had standards and policy targets for public transport access, but that the specifics of what was measured under each policy and the level of policy ambition varied significantly [31]. The standards and their policy targets for two cities, Sydney and Perth, are summarised in Table 3.

In alignment with SDG indicator 11.2.1, both cities' policies have a spatial measure of 'convenient access' to public transport. Depending on the transport mode, this ranges from 400 m (approximately a 5 min walk) for bus stops, to 800 m (approximately a 10 min walk) for train stations [32,33]. However, Sydney's standard specifies that 100% of residences should have proximate access, while in Perth, the policy target is only 60% of residences. Sydney's public transport standard is even more stringent, requiring both a proximate *and* frequent service (30 min for buses and 15 min for trains). These differences in standards and policy targets between Sydney and Perth has implications for the equitable realisation of the SDG goal in these two cities.

When policy-implementation was assessed [31], a city-wide average policy implementation of 38% was found to be achieved for Sydney. That is, 38% of residences in Sydney had frequent and proximate public transport services (Table 3). Unlike Sydney, Perth was found to be meeting its less ambitious policy target at the city-wide level; 64% of residences had proximate access to public transport, against the policy target of 60%.

However, given the cities had different policies, it was not possible to directly compare the cities' public transport policy access performance. When the two cities were compared using a common public transport metric previously found to be associated with increased active transport [34] (see national liveability indicator results in Table 3), only 18% of Perth addresses had access to frequent and proximate public transport within 400 m, compared with 38% of residences in Sydney [31]. This indicates that greater policy ambition in Sydney might be encouraging greater determination and investment overall.

The interquartile range results in Table 3 highlight that residences in different suburbs have varying levels of access to public transport, with less variation across suburbs in Perth than Sydney. While instructive, these results provide no indication as to where those variations are occurring. Spatial disaggregation of the results is therefore useful in identifying spatial inequities and areas

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Table 3
Public transport indicators for Sydney and Perth, Australia.

Indicator	Sydney	Perth
SDG indicator 11.2.1	Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities	
Policy standard	Households should be within an 800 m walk of an existing or programmed metropolitan railway station. . .served at least every 15 minutes, or within a 400 m walk of a bus route, accessing a metropolitan railway station. . .served at least every 20-30 minutes. [33]	At least 60% of dwellings should be in a safe 400 m walk from. . .an existing or potential bus stop, or in a safe 600 m walk from a railway station. [32]
Policy target	100%	60%
Policy implementation - city result	38%	64%
Policy implementation - suburb IQR	4%–68%	49%–81%
National liveability indicator	Percentage of residential dwellings within 400 m of a public transport stop with a scheduled service at least every 30 minutes between 7.00am and 7.00 pm on a normal weekday.	
National liveability indicator - city result	36%	18%
National liveability indicator - suburb IQR	4%–62%	0%–27%

Adapted from Arundel at al. [31].

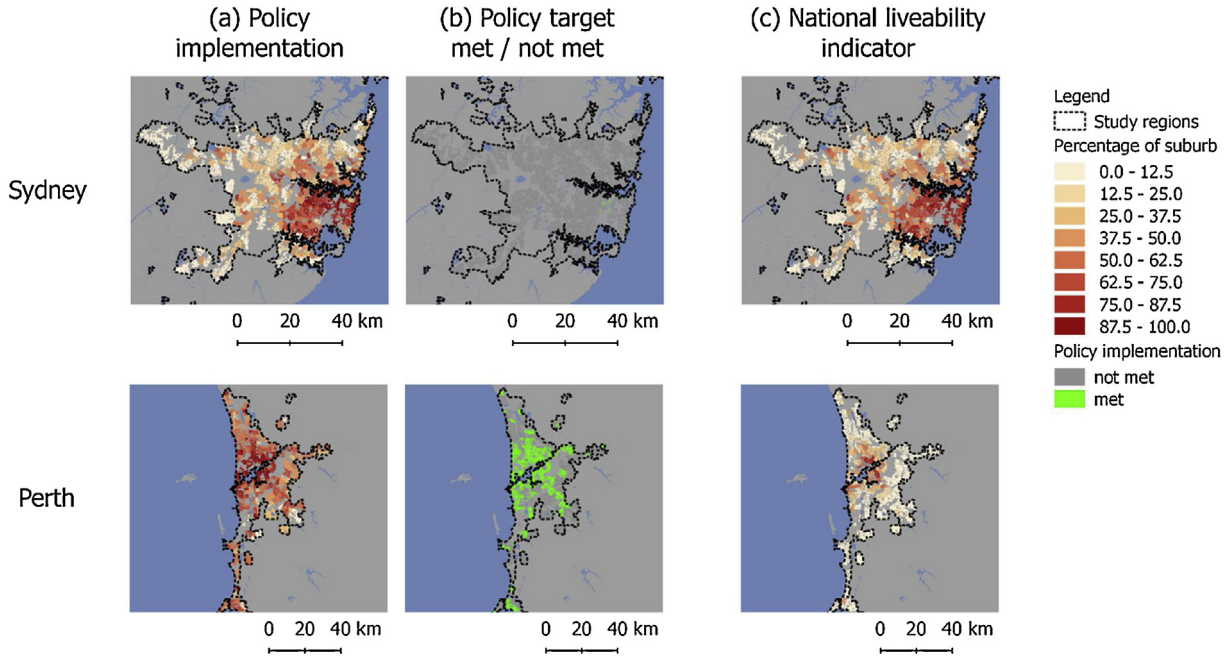

Fig. 3. Policy and national liveability indicator implementation in Sydney and Perth, Australia.
Adapted from Arundel et al. [31].

requiring further intervention across the cities. Fig. 3 shows spatial disaggregation of the indicators in Table 3, using three types of maps for the two cities.

Mapping policy implementation in Sydney at the suburb level (see Fig. 3(a)), showed generally higher levels of implementation in the southeast of the city, with poorer access in the north and west and especially on the urban fringe. Similarly, in Perth as distance from the central business district increases, policy implementation generally decreased. Fig. 3(b) shows that significantly fewer Sydney suburbs (2%) are meeting the state's stringent (yet desirable) public transport access target, compared with 54% of Perth suburbs (mainly inner and middle suburbs) meeting that state's more modest policy target. The final map (Fig. 3(c)) also takes frequency of service into account and allows the cities to be directly compared, clearly showing the spatial distribution of services within cities. It shows that few Perth suburbs are achieving a proximate and frequent public transport service; with only inner suburbs enjoying this level of access.

Importantly, the spatially disaggregated results in both cities highlight areas in the city where there are spatial inequities in public transport access, including those falling well short of the state government public transport policy targets. This can assist city planners to identify areas requiring focussed interventions and investment.

4. Discussion

There is a maxim that 'what gets measured gets done'. To this end, indicator frameworks have been developed by the UN to benchmark and monitor progress towards achieving the SDGs [24,26]. In this paper, we reviewed the SDGs and NUA indicator frameworks, and identified indicators related to city planning and health. These frameworks offer the potential for focused and uniform city indicator measurement globally. However, despite the importance of city planning for the achievement of numerous SDGs, we found no specific city planning indicators for nine of the 17 SDGs,

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which ignores the importance of spatial planning for achieving those goals. We also found a mismatch between the city planning and health indicators included in the SDG and NUA indicator frameworks, which may cause confusion and inconsistencies for cities attempting to benchmark and monitor their performance.

As shown in Fig. 2, cities that follow the UN's SDG indicator framework will omit critical upstream indicators of the technical, regulatory, and legislative policies, interventions or investments that are likely to determine whether or not the SDGs are achieved [5,6]. For example, although the SDG framework includes indicators of air pollution, which is a key health risk exposure [35], it fails to include indicators measuring legislated limits to air pollution; or transport policies or investment designed to improve air quality by increasing active transport or public transport use.

Conversely, cities that adopt the NUA indicator framework, which appropriately measures a number of urban design and transport planning interventions, will omit important downstream indicators that assess the outcomes of policy implementation. Notable omissions in the NUA indicators relevant to this paper, are those measuring injury and health outcomes. However, indicators of key urban systems are also omitted.

While both frameworks measure crime, neither measures policies nor interventions designed to reduce crime. Although both indicator frameworks focus on increasing access to safe drinking water and sanitation as key determinants of disease outcomes [35], no indicators measure water and sanitation policies or investments. Equity is a major theme within the SDGs and NUA [7], but with the exception of public transport, there was a dearth of indicators measuring the presence or absence of basic services such as education, healthcare, and social and community services [28]. As structural determinants of health [36], equitable spatial access to these services in cities is vital for achieving desired educational and health outcomes.

Our analysis of the SDG and NUA indicator frameworks highlighted that many of the indicators to be used by cities, are grouped according to topics or Goals (e.g. SDG 11 has indicators of policies, investments, design intervention, daily living outcomes and risk exposures), rather than clearly distinguishing between upstream determinants of downstream outcomes. This makes it difficult to identify the temporal sequence about how action on upstream determinants might influence intermediate determinants and downstream health outcomes, providing limited guidance to decision-makers about where they should focus attention.

Ideally, indicators allow cities to benchmark and monitor the implementation and outcomes of policies and interventions, and when spatially disaggregated and mapped, identify spatial inequities within and between cities [28]. We found that - if local data were available - the majority of SDG and NUA indicators related to city planning and health allow for spatial disaggregation. The case study of public transport indicators measured across Australian cities demonstrates the value of doing so to measure spatial inequities. It also illustrates how policy-relevant indicators can be used to assess each city's progress towards implementing policies that could help achieve the SDGs [31]. Yet, the value of having common indicators, allowing between-city comparisons was also highlighted.

Creating indicators is time consuming and may be burdensome, particularly for cities in developing countries where access to appropriate high-quality data may be lacking. This may limit their ability or willingness to measure progress towards achieving the SDGs. Hence, inclusion of indicators on the presence or absence of urban system policies (e.g., transport policy designed to encourage public transport and/or active forms of transportation) in the SDG and NUA frameworks is not only important because of their impact downstream, but also because they are easily measured. This would enable a wider range of cities and countries to report their progress towards implementing policies that might achieve the SDGs. However, in the future, with the emergence of open data sets and global standards for data collection, there will be new opportunities for measurement of city planning on-the-ground. Adopting standards for data collection will be important, if cities are to be compared.

To this end, the International Organization for Standardization (ISO) in conjunction with the World Council on City Data (WCCD) have mapped their set of city services and quality of life indicators against the SDG-related indicators. ISO 37120:2018 [39] is supported by additional standards currently under development, focussing on smart cities [40] and resilient cities [41]. The standardisation of indicators and creating routinely collected indicators has obvious advantages for reducing the burden on cities; and enabling cities to be compared. However, the ISO and WCCD approach makes no attempt to spatially disaggregate their indicators; rather each city reports only a single result for each indicator for the city as a whole. This limits it usefulness for city planners and fails to unmask health inequities as advocated by the World Health Organization [28], and as we have argued for in this paper.

4.1. Limitations

This paper has a number of limitations. We examined the SDG and NUA indicators against an established health-related framework focussed on a limited number of health outcomes and upstream determinants. For example, our focus was on spatial planning, and we did not consider provision of energy which could be included in future studies. The conceptual framework for analysis also only identifies hypothesized upstream-downstream pathways to promote health and enhance sustainability. Although associations with health outcomes have been identified [6], there is no guarantee that implementing upstream policies will change outcomes downstream: this requires evaluation [37,38]. Nevertheless, one strength of using a framework, was that it provided clarity on the types of indicators that may be important to achieve desired outcomes, and perhaps even more importantly, a systematic approach to guide decision-making about the interventions required to bring about change.

With our focus on spatial planning, we also only considered spatial inequities in the distribution of city planning interventions, rather than inequities more generally. Although beyond the scope of this paper, future research could consider indicators of broader equity issues, such as environmental justice, and marginalisation based on socioeconomic status, gender or race.

Only two authors evaluated the indicator frameworks, and one author was an arbiter. Although we assessed inter-rater reliability between the two evaluators and discussed and resolved any differences in how indicators were classified, our approach could have led to bias.

5. Conclusion

Globally, cities are growing at an unprecedented rate, and the decisions we make about how we design, build, manage and govern our cities will profoundly influence the health and wellbeing of urban dwellers, and the extent to which cities can achieve the UN SDGs. The current SDG global indicator framework falls short of guiding decision-makers about the upstream policies and interventions required to achieve the desirable health and sustainability outcomes specified in the SDG goals. While the NUA framework attempts to fill this gap for cities, there are inconsistencies in the NUA and SDG indicator frameworks, which may cause confusion. Ideally a more comprehensive set of indicators for cities could be developed, that enable cities to benchmark and monitor the imple-

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mentation of their own policies but also to use a common set of city indicators that enables between-city comparisons. Cities could be given some guidance about evidence-based targets for each of their indicators, based on the level of intervention required to achieve health and wellbeing outcomes. This will avoid the unintended consequence of cities setting policy targets that are too low to achieve desirable outcomes. Ideally, cities will use spatial data that will enable them to identify spatial inequities within cities. However, given that some cities will struggle to access spatial data, it is recommended that – at the very least – they are encouraged to adopt indicators that enable them to measure the presence or absence of urban system policies and investments. These could potentially drive on-the-ground interventions that will determine longer-term health and sustainability outcomes.

Conflict of interest

There are no conflicts of interests.

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